

Architectural Effects on Impact Resistance of Uncoated MI SiC/SiC Composites

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Background

- Turbine components are subjected to impact damage by soft and hard projectiles.
- Projectile impact can cause spallation of surface coating, substrate damage, and eventual loss of components depending on impact velocity.
- Understanding influence of impact damage on properties and methods of avoiding or reducing impact damage are essential for development of CMC components

Impact Study

- **Objectives**

- Near Term

- Determine influence of fiber architecture on impact damage mechanisms of uncoated MI SiC/SiC composites at room and high temperatures.

- Long Term

- Determine influence of oxidation on properties of impact tested uncoated and environmental barrier (EB) coated MI SiC/SiC composites.

- **Approaches**

- Impact test room and high temperatures
 - Vary impact testing parameters
 - Evaluate impact damage using NDE techniques
 - Deposit EB coatings on MI SiC/SiC composite specimens
 - Expose impact tested specimens in moisture environment at high temperatures
 - Measure residual mechanical properties at room temperature

Material and Experimental Variables

- Material

Composite Vendor: Goodrich

Composite characteristics : BN/SiC coated Hi-Nicalon-S SiC fibers, 8 ply, 0/90, 5HS Weave, 18 epi and 2 different 2.5D woven structures, Melt infiltrated (MI) matrix.

Impact test variables

Projectile: 1.59mm dia steel balls

Projectile velocity: 115 to 300 m/s

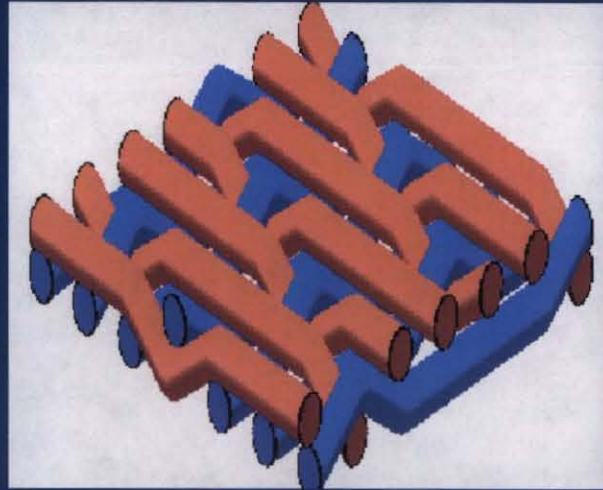
Test temperature: 25⁰ and 1316⁰C

Test environment: Air

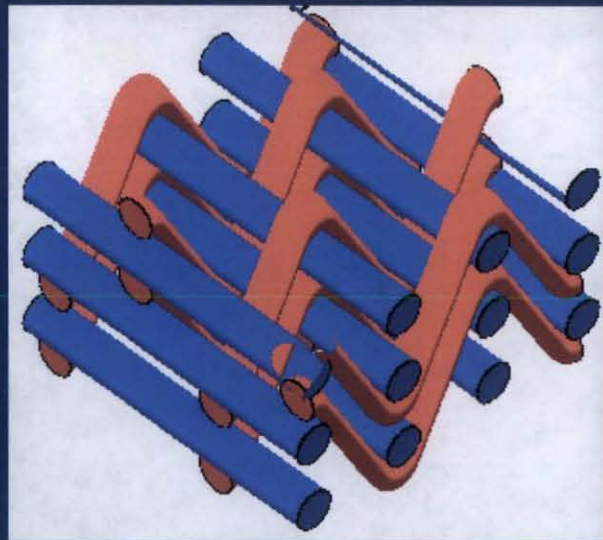
- Characterization methods

Optical microscopy, Thermography, Computed Tomography (CT)

Fiber Architecture



(a) Harness satin weave



(b) Layer angle interlock

Optical Photographs of the Cross Section of 2-D and 2.5D MI SiC/SiC Composites



2-D

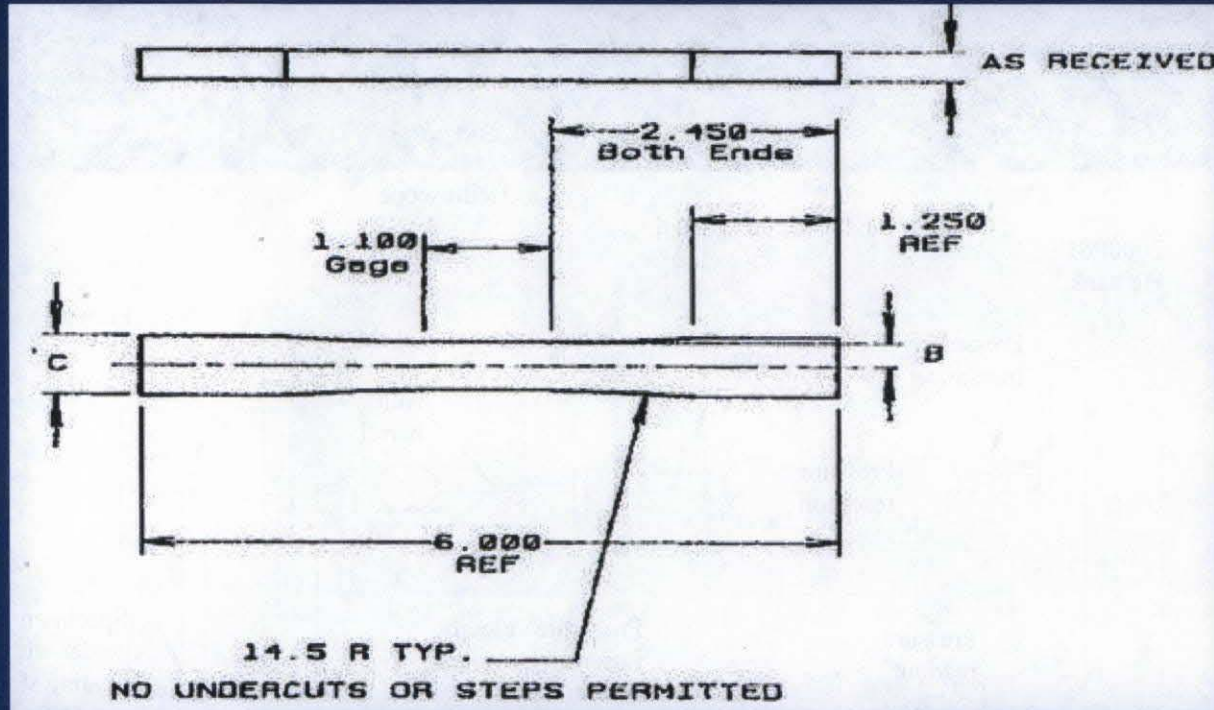


2.5-D (Type I)



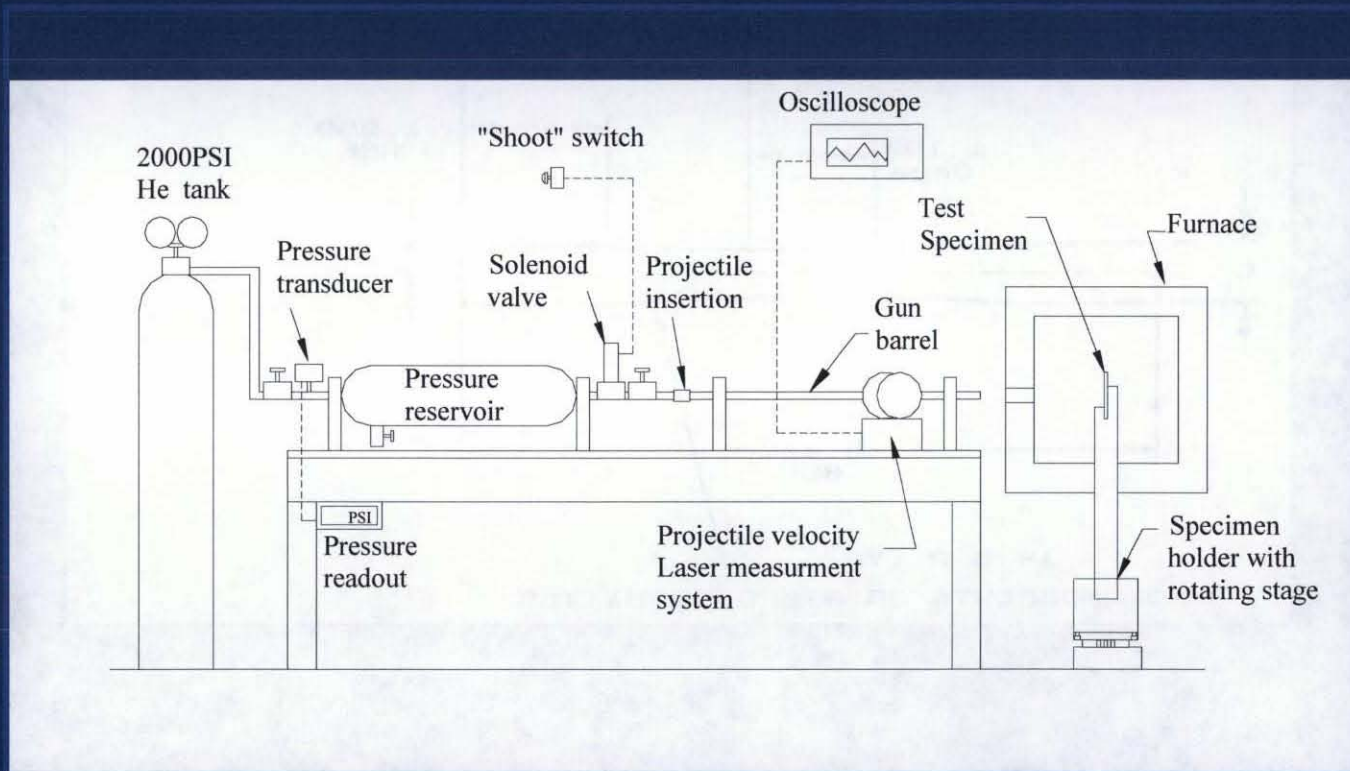
2.5-D (Type II)

Impact Specimen Geometry



Note: All dimensions are in inches

Impact Facility



High-temperature capability up to 1500°C

Optical Photographs of 2-D MI SiC/SiC Composites Impact Tested at 1316°C in Air

Impacted side

Back side



115m/s

Impacted site



160m/s



Damage zone

220m/s



300m/s

Thermographic Images of 2-D MI SiC/SiC Composites Impact Tested at 1316°C in Air

Impacted side

Back side



115m/sec



160m/sec



220m/sec



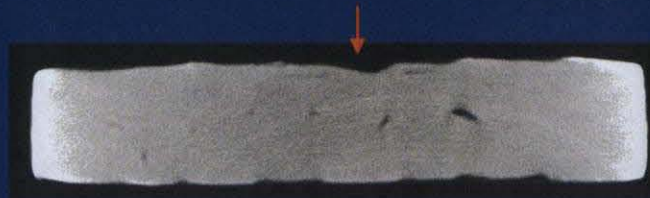
300m/sec

CT Images of 2-D MI SiC/SiC Composites Impact Tested at 1316°C in Air

115 m/s



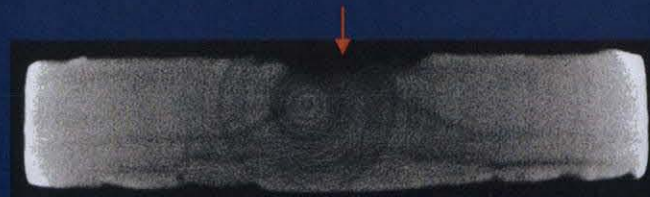
160 m/s



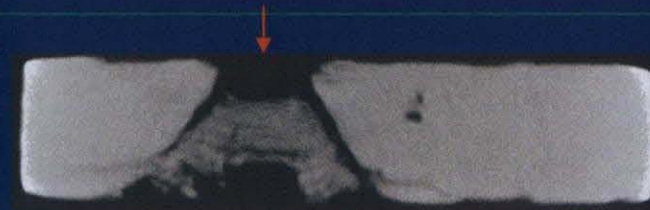
220 m/s



300 m/s



325 m/s



Optical Photographs of 2.5-D (Type II) MI SiC/SiC Composites Impact Tested at 1316°C in Air

Impacted side

Back side



115m/s



160m/s



220m/s



300m/s

Thermographic Images of 2.5-D (Type II) MI SiC/SiC Composites Impact Tested at 1316°C in Air Using 1.53-mm Dia. Steel Projectiles

Impacted side

Back side



115m/sec



160m/sec

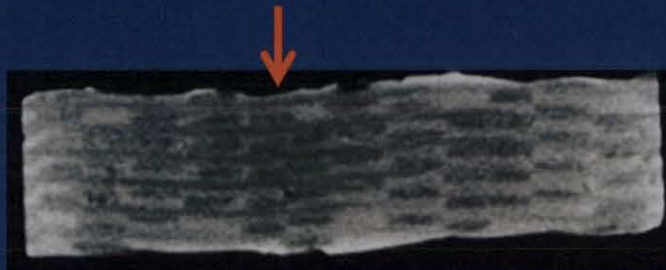


220m/sec

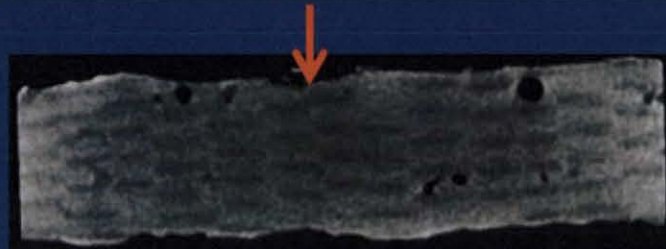


300m/sec

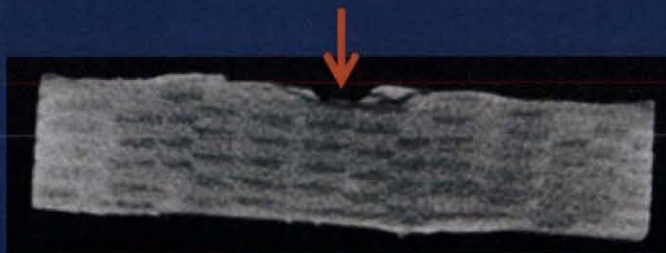
CT Images of 2.5D (Type II) MI SiC/SiC Composites Impact Tested at 1316°C in Air



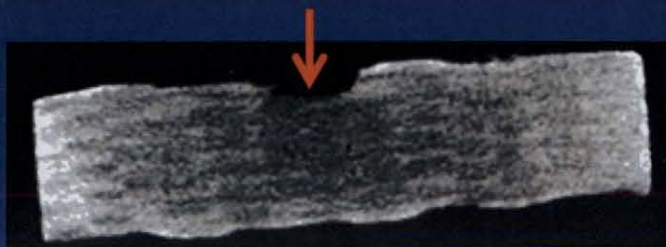
115m/s



160m/s

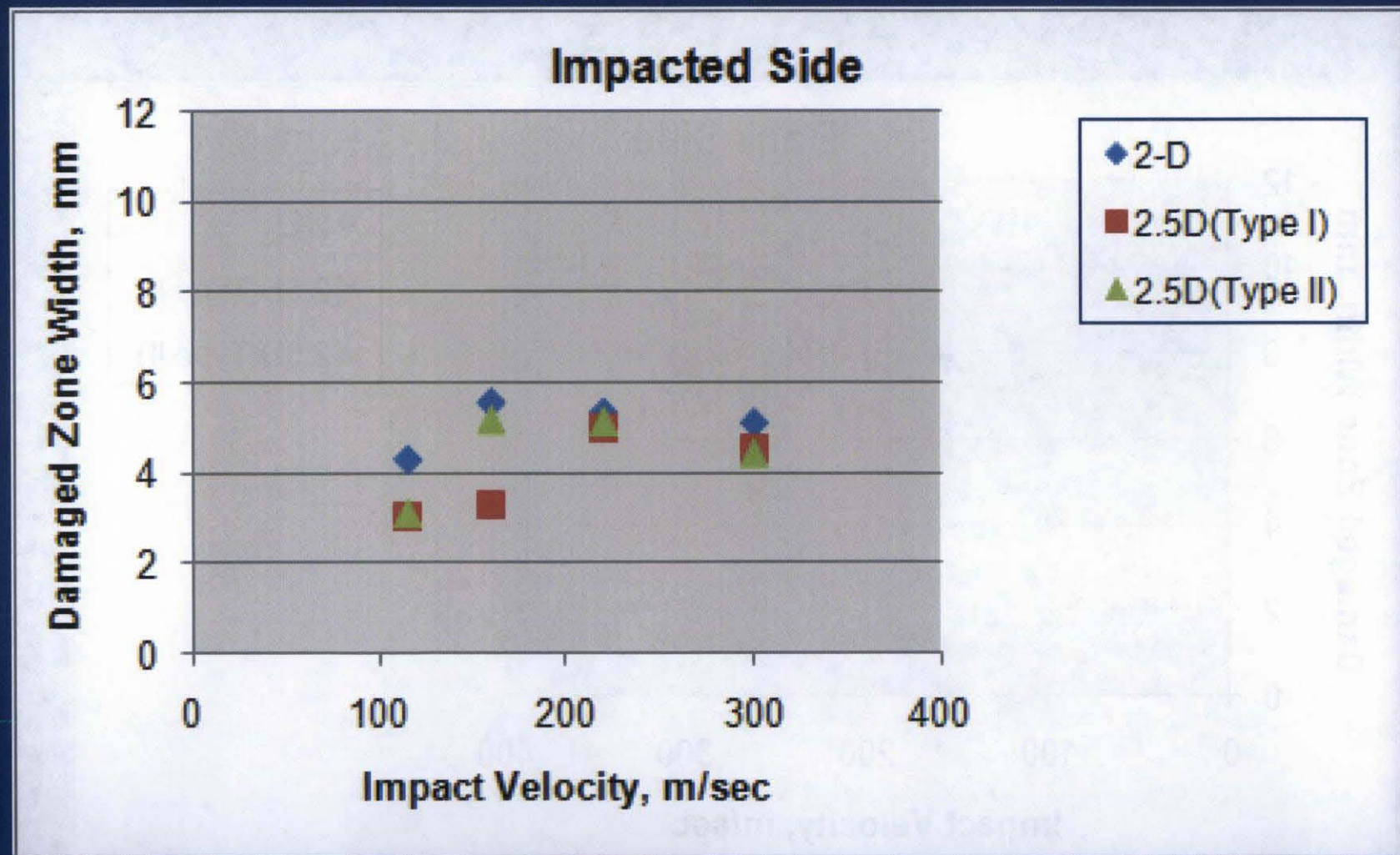


220m/s

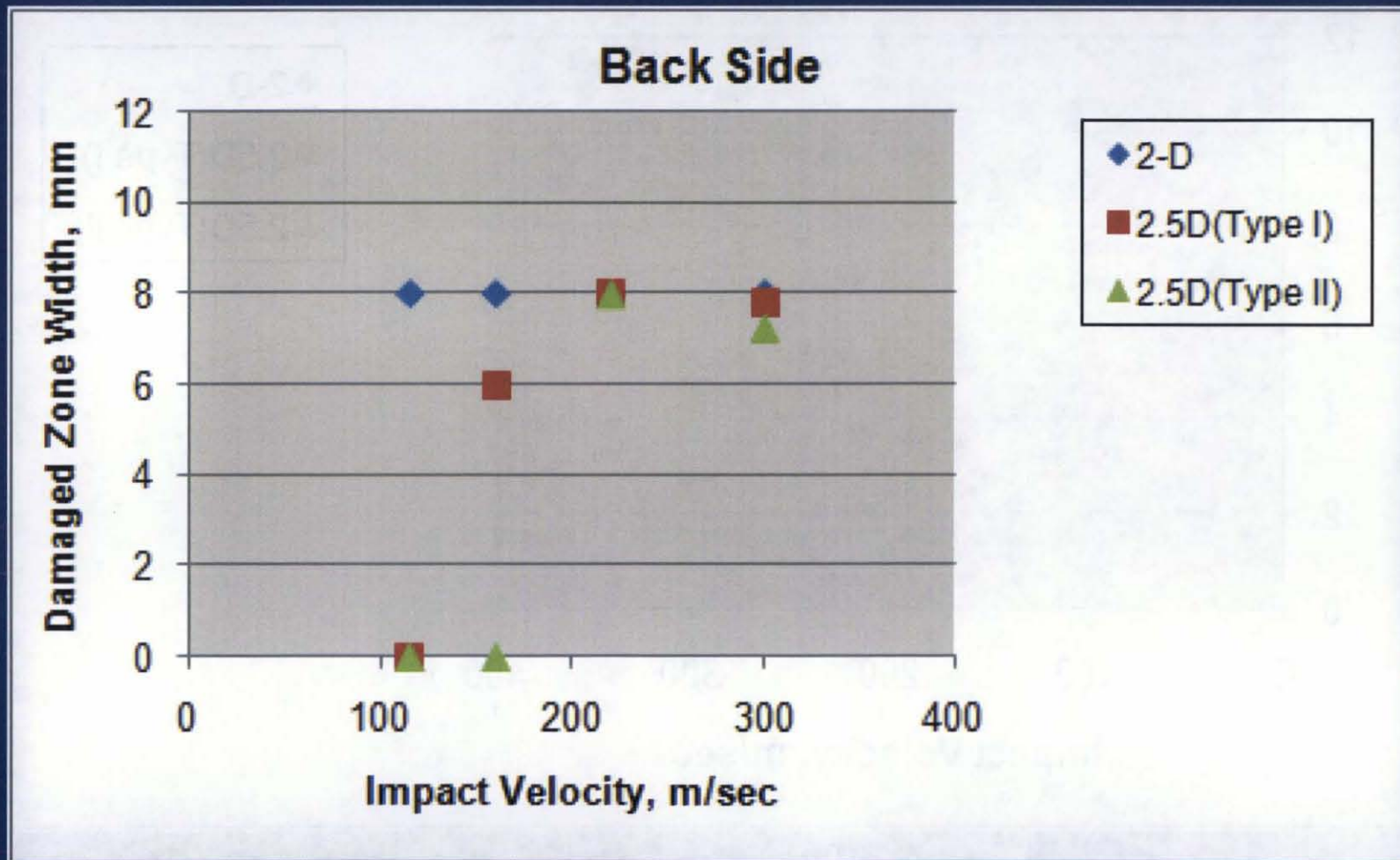


300m/s

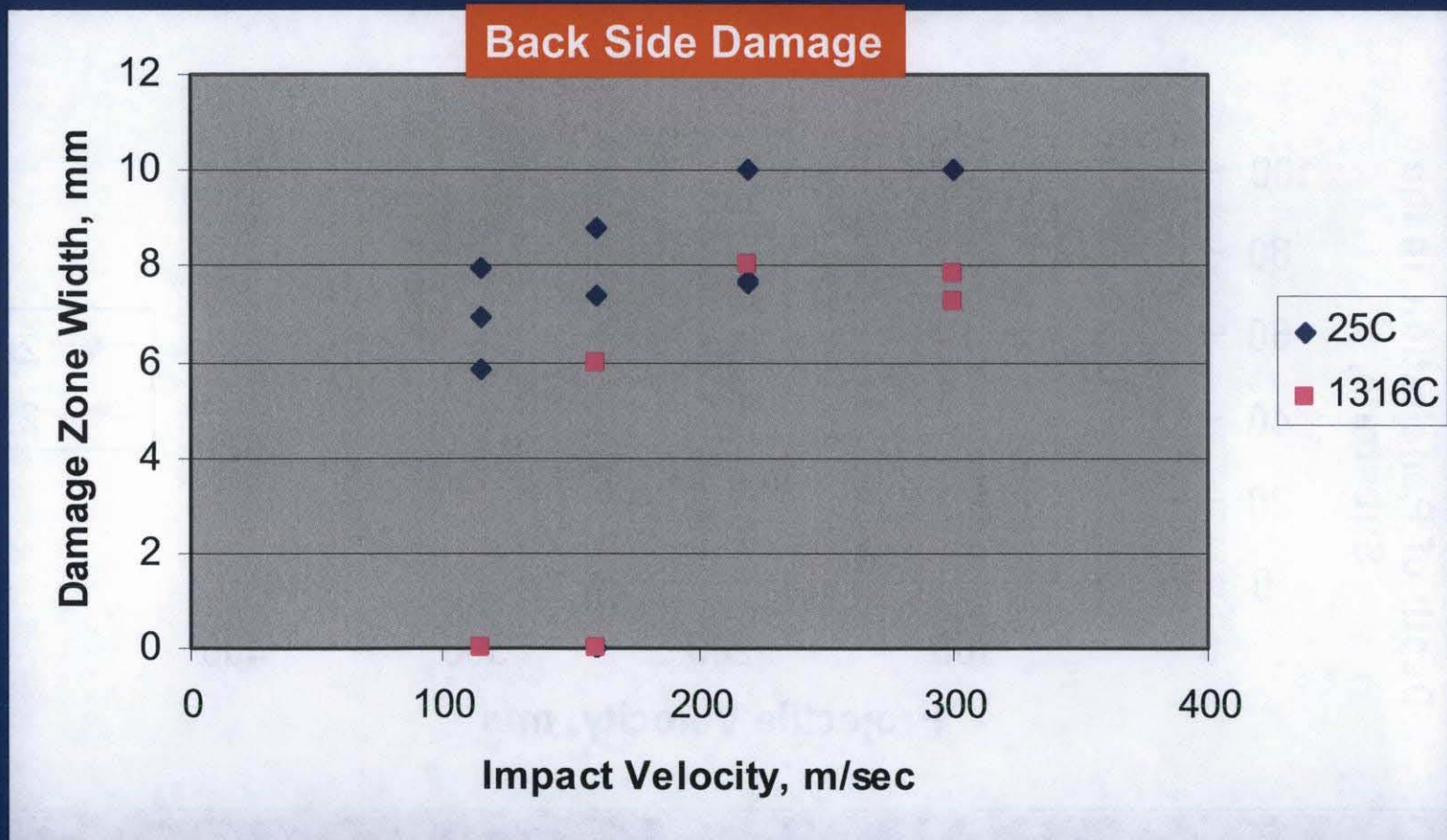
Comparison of Damage Zone Width with Projectile Velocity for 2D and 2.5-D MI SiC/SiC Composites Impact Tested at 25°C In Air (Thermography Data)



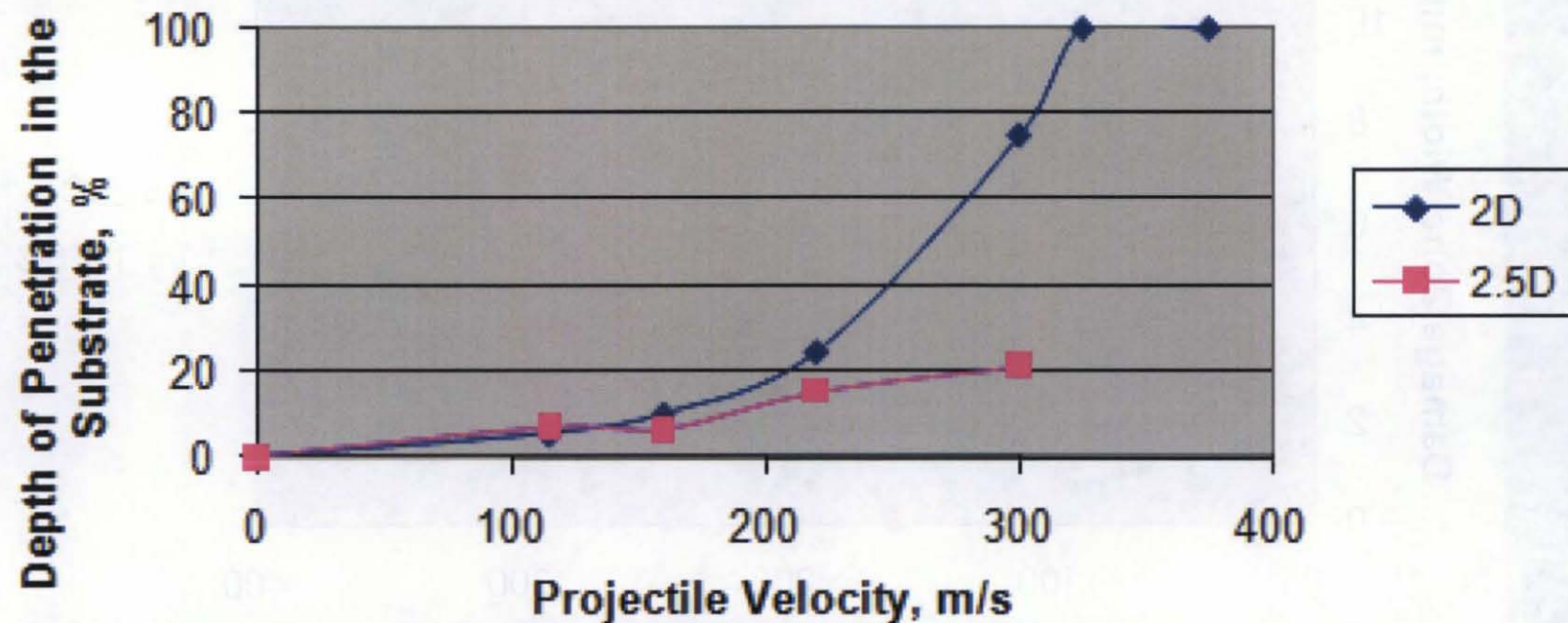
Comparison of Damage Zone Width with Projectile Velocity for 2D and 2.5-D MI SiC/SiC Composites Impact Tested at 1316°C In Air (Thermography Data)



Comparison of Damage Zone Width with Projectile Velocity for 2.5-D (Type I and II) MI SiC/SiC Composites Impact Tested at 25⁰ and 1316⁰C in Air (Thermography Data)



Variation of Damage Zone Depth with Projectile Velocity for 2-D and 2.5D MI SiC/SiC Composites Impact Tested at 1316°C in Air (CT Data)



Summary of Results and Conclusion

Summary of Results

Impact tests were conducted on uncoated 2D and 2.5D MI SiC/SiC composite specimens at room temperature and 1316°C in air. The specimens were analyzed before and after impact using optical microscopy, pulsed thermography (PT) and computed tomography (CT). Preliminary results indicate the following.

- Both 2-D and 2.5D composites show increase in surface and volumetric damages with increasing impact velocity. However, 2-D composites are prone to delamination cracks.
- In both 2D and 2.5D composites, the magnitude of impact damage at a fixed impact velocity is slightly greater at room temperature than at 1315°C.
- At a fixed projectile velocity and test temperature, the depth of penetration of the projectile into the substrate is significantly lower in 2.5D composites than in 2D composites.

Conclusion

Fiber architecture plays a significant role controlling impact damage in MI SiC/SiC composites.

Future Plans

- Determine influence of impact damage on properties of uncoated and environmental barrier coated MI SiC/SiC composites.
- Develop analytical models to predict impact damage